

2808

Yield Trials of Steroid-producing *Dioscorea* on Florida's Everglades Peat Soils

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Four steroid-bearing clones of Dioscorea tested in a replicated varietal trial on Everglades peat soil near Belle Glade, Florida, included three introductions of D. spiculiflora Hemsl. and one selection of D. composita Hemsl.

On an acre basis, D. composita, P. I. 201783, produced over 21 tons of dry tubers and 1,049 lbs of crude sapogenins. Tuber and sapogenin yields from the highest producing D. spiculiflora, P. I. 252887, were approximately 1/3 and 1/2 respectively, of these amounts.

Yield differences were not significant between plots harvested 2 1/2 and 3 1/2 years after planting. The failure of tubers to increase in size in the last growing season was attributed to the restriction on growth imposed by the high water table at the test site.

Introduction

In the last two decades, steroid hormones have become a very important group of pharmaceuticals, used as birth-control drugs, in anti-arthritic medications, and for many other clinical applications. The sapogenins extracted from *Dioscorea* species represent the principal source of basic materials from which these drugs are prepared. The harvesting of various wild *Dioscorea* species for extraction of sapogenins has become an important industry in some localities; the

largest is based on the extensive natural stands of *D. composita* Hemsl. and *D. floribunda* Mart. & Gal. in southern Mexico.

The United States Department of Agriculture has, for several years, studied the suitability of these and other species for commercial plantings. Propagation methods have been studied at the Plant Introduction Stations at Glenn Dale, Maryland, and Miami, Florida, and at the Federal Experiment Station at Mayaguez, Puerto Rico (4, 5). Field experiments have been conducted at Miami and Mayaguez (3,4,6). In a nutrition study at Miami, mineral deficiency symptoms were induced to provide information about nutritional requirements (2).

At this time, the Department of Agriculture is continuing *Dioscorea* investigations only at the Mayaguez station in Puerto Rico, where private concerns have begun commercial production of the crop. This paper reports the final experiment conducted in Florida, on the Everglades peat soils of Palm Beach County.

The first tests in Florida were conducted in Dade County, on shallow, sandy soil overlying oolitic limestone, at the Plant Introduction Station at Miami. Plant growth and tuber production were promising, but no practical method was found for harvesting the tubers which invariably penetrated crevices in the limestone subsoil. Test plantings were then made on the deep sand soils of the Fort Lauderdale area and the peat soils at

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Belle Glade. Growth was very slow on the sandy soils, but excellent growth and tuber yields were achieved at Belle Glade, despite regular winter-season injury to aboveground portions of the plant. The tubers were easily harvested by hand excavation from the soft peat soils.

In the spring of 1961, a replicated varietal trial was planted on the University of Florida Everglades Experiment Station site near Belle Glade, Florida, in a cooperative evaluation project conducted by staff members of the Plant Introduction Station at Miami and the Everglades Station. This paper reports the results of that experiment.

Materials and Methods

Four asexually propagated clones of two species were utilized in this test. Selection of the three introductions of *D. spiculiflora* Hemsl. was based upon the high sapogenin analyses of the original material introduced from Mexico (8.0 to 8.2% moisture-free basis). The fourth clone was propagated from a highly vigorous seedling (designated F13) of *D. composita*, P. I. (Plant Introduction) 201783. The original tuber analysis for this *D. composita* introduction was relatively low (2.8%, m.f.b.), but the tuber yield and vine growth were exceptional in preliminary trials.

Single-leaf cuttings were rooted in mist propagation beds in February, and six weeks after sticking, were transferred to compressed peat pots and held in the greenhouse until field-planted in early June. Most contained four to six leaves at that time, and fibrous roots were appearing through the pots. The pots were set in the ground with the plants, and, consequently, the root systems were not disturbed by transplanting. Plants were spaced at 18 inches in rows three feet apart in five randomized complete blocks.

Before planting, the field site was treated with 1,600 pounds of sulfur per acre, to increase soil acidity. After the plants were established, 600 lbs/A of sulfur and 500 lbs/A of 0-8-24 fertilizer were applied in bands.

In previous trials at Belle Glade, *Dioscorea* plants were found difficult to establish because of severe weed competition. In this test black polyethylene plastic two mils thick

and 24 inches wide was used as a soil cover within the planted row during the first season. This allowed the comparatively slow-growing young vines to become established with minimum weed competition. The plastic proved effective for this purpose and by December, the end of the first growing season, the vines were well established. It was not necessary to employ plastic mulch during subsequent growing seasons. With the benefit of occasional between-row cultivation and a small amount of hand weeding around individual plants, new shoots arising from established tubers grew rapidly and competed successfully with weeds.

A split-split plot design was selected to provide varietal comparisons and to test differences resulting from two lengths of field growth before harvest and from two types of vine support. Comparisons were planned between continuous vine supports of woven wire and individual bamboo stakes, both four feet high. Vine growth was so vigorous that it became evident early in the second growing season that the subplot plants could not be kept separated without severe pruning. Pruning was considered undesirable; therefore, the vines were permitted to cross rows between subplots. Before the end of the second growing season, the vines produced a dense canopy which spread across all supports completely covering the area.

One half of the planting was harvested in February 1964, the remaining part in March 1965. The tubers were hand dug after vines and supports had been removed. After weights were recorded, tubers were chopped with a wood chipper and duplicate composite samples from each plot analyzed by the method of Wall (7) at the Eastern Utilization Research Development Division Laboratories in Philadelphia, Pennsylvania.

Concurrently with these tests, a limited study was made at Miami to determine the photosensitivity of the clones used in the Belle Glade plantings. These tests indicated that the *D. spiculiflora* clones stopped growth with the advent of short days while *D. composita* continued growing. This observation was corroborated with data from field-grown plants, by marking leaves and stems of both species in late September when day length reached 12 hours.

Results and Discussion

Fresh and dry tuber weights and sapogenin yields for the 1964 and 1965 harvests are given in Table I. These data show that tubers of *D. composita* develop at a much faster rate than those of *D. spiculiflora*. Test results showed highly significant differences between species for tuber yield. Slow tuber growth is a species characteristic of *D. spiculiflora*. The value of *D. spiculiflora* for commercial use is reduced by the mixture of its sapogenins which makes separation difficult. This species would be grown only if yields were higher than those of *D. composita*. Since the reverse is true, *D. spiculiflora* is not of interest as a crop for cultivation at the present time.

Tuber and sapogenin yields of the two harvests were not significantly different. This was an unexpected result, since, in experiments in Puerto Rico, *D. composita* tubers are reported to continue enlarging over a four-year period (1). No comparable information about *D. spiculiflora* is available. At Belle Glade the *D. composita* tubers reached the water table at or before the time of the 1964 harvest, and did not grow thereafter. These results suggest that no advantage would accrue from permitting the plants to remain in the field more than two and a half years.

In all trials, the percentage of sapogenins increased between the first and second harvests. However, net yields of sapogenins did not increase significantly. The green weights

of tubers from the two harvests were nearly equal, but tubers from the second harvest contained considerably more moisture. The percentage of dry weight of all tubers was 18.3% less in 1965 than in 1964. Expressed on a dry weight basis the weight of tubers harvested was actually less in 1965 than in 1964.

We find no adequate explanation for the drop in dry weight percentage after the first harvest. Examination of the tubers revealed that the distal ends of many had decayed in 1965. This was more evident on the larger tubers of *D. composita*, although some of the *D. spiculiflora* tubers also had decayed. Many tubers of both species had reached the water table in 1965, and we assume that this was responsible for deterioration of the lower portions.

These results suggest that on the peat soils of the Belle Glade area *Dioscorea* should be harvested after two growing seasons and the actual growing time be extended by earlier field planting. To accomplish this, stem cuttings could be taken from rapidly growing field plants during middle to late summer. Production costs might be greatly reduced by rooting the cuttings in protected outdoor beds and carrying the new plants through the winter in the same beds.

As already mentioned, in Puerto Rico, yields of *D. composita* increased in the fourth growing season. The plants might be grown for four seasons in the Belle Glade area where the water table can be controlled to provide a greater depth of unsaturated soil. If tubers were allowed to grow to

TABLE 1
YIELD OF DIOSCOREA INTRODUCTIONS AT 2½ AND 3½ YEAR HARVESTS.
YIELD DATA REPRESENT MEANS FROM 5 REPLICATES, CONVERTED TO AN ACRE BASIS.

	Age at harvest, years	Total fresh weight, lbs/A	Total dry weight, lbs/A	Sapogenin analysis (m.f.b.) %	Total sapogenin yield, lbs/A
<i>D. composita</i>	2½	164,947	42,301	2.48	1,049
P. I. 201783	3½	172,884	35,235	2.80	987
<i>D. spiculiflora</i>	2½	36,493	12,390	1.32	164
P. I. 252684	3½	34,848	10,067	1.92	193
<i>D. spiculiflora</i>	2½	56,628	19,747	2.10	415
P. I. 252887	3½	65,243	19,457	2.42	471
<i>D. spiculiflora</i>	2½	33,492	8,615	3.16	272
P. I. 253106	3½	33,686	6,679	4.12	275

greater depths, harvesting problems would be increased. A large and specially designed harvesting machine would be necessary but could be justified by the greater returns from the crop.

Extrapolated to an acre basis, the yield of dried tuber material from the *D. composita* grown in this experiment exceeds 21 tons at the two and a half year harvest. At current prices the value of this material is approximately \$3,570.00 or \$1,428.00 per year (4).

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